Nano Patterned Titanium for Orthopedic Applications

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Abstract: The structure of implant surfaces plays an important role in the interaction between the implant and its surroundings because it is in direct contact with living tissue[1]. Since tissues are known to have nanostructures, the development of implants with surfaces that mimic this type of structure is a crucial factor in allowing the tissue to recognize the implant and therefore exhibit better adhesion properties. This study involves examining osteoblast function on nano patterned titanium substrates created using electron beam evaporation. These patterns appear to better promote bone cell functions more similar to long bones of the body. As a result of mimicking the structure and properties of bone, initial formation of anisotropic bone upon implantation will occur.

I. INTRODUCTION

Research has shown that the use of nanophase metals, especially titanium and titanium alloys, result in enhanced osteoblast (bone-forming cells) adhesion. By creating implant surfaces that match the nanostructure topography of the natural extracellular matrix proteins in bone tissue[2], the surrounding tissue will recognize the implant and promote osseointegration. Much research has been conducted to determine the best nanophase metal to coat implants, as well to develop different coating processes that will maximize surface area and thereby adhesion. Yet one aspect that has not been researched to date is creating a surface with linear anisotropic nano patterns matching natural long bones in the body. For this reason, the objective of this study was to fabricate titanium with biologically-inspired anisotropic nano features similar to hydroxyapatite and collagen in long bones.

II. MATERIALS AND METHODS

To create titanium surfaces (McMaster-Carr 99.2% pure titanium) containing linear nanostructured features, electron beam evaporation method was used in this study. This technique concentrates large amounts of heat produced by high energy electron beam bombardment on the material to be deposited. The electron beam was generated by an electron gun that used thermoionic emission of electrons produced by an incandescent filament. A magnet focused the electron trajectory so that the beam was accelerated towards a crucible containing the material (i.e., titanium) to be evaporated. As the beam hits the surface of the evaporant, heat and vaporization occurs. The vapor flow was then deposited onto the titanium substrate surface located at the top of the machine. The linear nano pattern was created on the surface of the titanium by attaching a grid (Electron Microscopy Sciences, G400P-Cu) on the substrate before being placed into the e-beam evaporator. Once these patterned titanium substrates were created, they were characterized by scanning electron microscopy. Functions of bone cells will also be reported on these nano patterned Ti surfaces.

III. RESULTS AND DISCUSSION

Results of this study provided a technique that can be used to pattern nanoparticles of titanium onto a titanium implant surface (Fig. 1). Fig. 1 clearly shows the nanostructured roughness in the linear patterns on titanium.

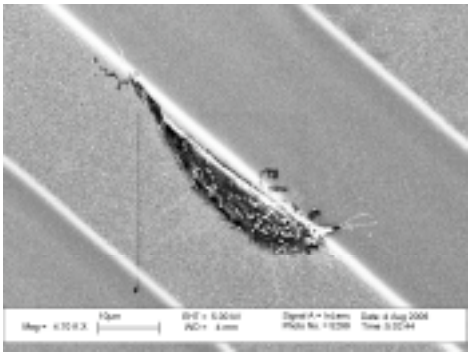

Fig. 1. Control of osteoblast alignment for the next generation nanotechnology derived bone implant (bar=10um).

Since previous studies have shown increased osteoblast adhesion on random nanostructured titanium surfaces[3], it is the goal of this study that such

nanopatterned anisotropic materials will promote bone cell functions more similar to long bones of the body.

IV. CONCLUSIONS

Results of this study provided a technique which creates aligned features of nanostructures similar to what is observed in long bones of the body. Such materials deserve further investigation towards improving orthopedic applications.

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